

DOCTOR OF ENGINEERING INTERNSHIP

At Cameron Iron Works

An Internship Report

by

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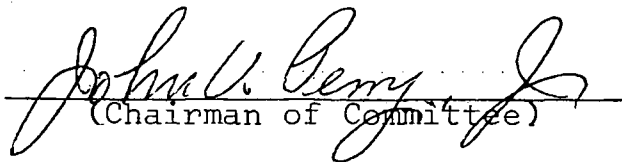
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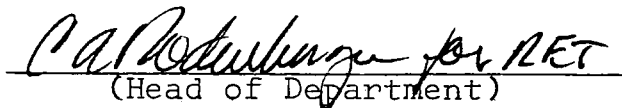
An Internship Report

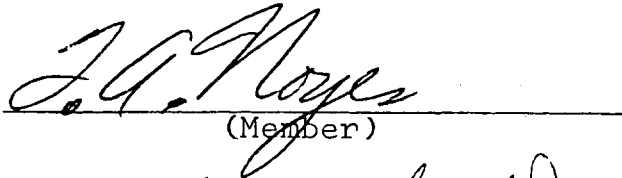
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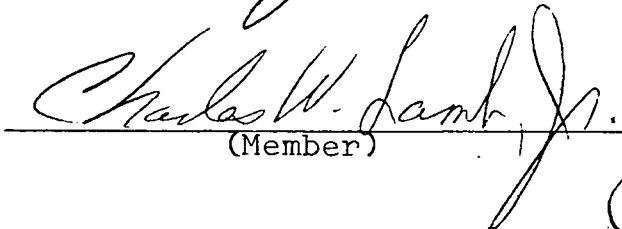
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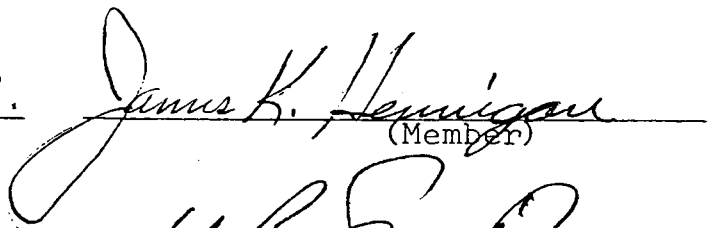
  
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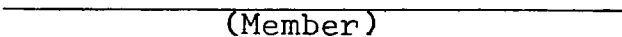
  
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May 1979

## ABSTRACT

Intern Experience at Cameron Iron Works, Inc.

Marine Systems Group located in Houston, Texas. (May, 1979)

John Stoud Platou, B. S., Texas A&M University

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Chairman of Advisory Committee: Dr. J. V. Perry

This report deals with the eighteen months of professional engineering experience and the six months of non-engineering experience gained by the author during a twenty-four month internship with Cameron Iron Works in the Marine Systems Group under the direction of Mr. E. A. Fisher.

The three major assignments in product design and development and assignments in non-engineering are presented. Problems with the evaluation of the ball joint line are presented and the author's solution is detailed. The pressure seals in a Cameron Control Systems have been a source of customer dissatisfaction in recent years. The author's assessment of the problem and solutions are also presented. The problems associated with the redesign of a set of angloimeters are discussed and solutions are given. Non-engineering assignments and experience are also outlined. The non-engineering areas included sales, service, market forecasting and information systems.

## ACKNOWLEDGEMENTS

Utmost appreciation is expressed to..

..Dr. J. V. Perry for acting as my committee Chairman and guiding me through the program.

..Mr. E. A. Fisher for supervising my internship at Cameron Iron Works and for his assistance in obtaining non-engineering assignments.

..Mr. T. A. Noyes, Dr. Charles Lamb, and Dr. J. Hennigan, my committee members, for their endless help with my program and career.

..Dean Charles A. Rodenberger for his help in securing an internship.

DEDICATION

to Linda

Tammie

Rock

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## INTRODUCTION

This report documents the internship experience gained by the author during a 24 month Doctor of Engineering Internship at Cameron Iron Works. The location of the position was at Cameron's engineering complex on Katy Road in Houston, Texas, although the author's assignments required travel to other Cameron facilities and to customers' offshore locations. The author was employed by Cameron Iron Works as a product design engineer and was considered a permanent, full-time employee.

This report details the three major engineering projects assigned to the author during this period and their solutions. It also outlines the experiences of the author during a six-month portion of the internship which was spent in areas other than engineering. An overview of the author's contributions to his community is also presented.

The internship is a required part of the Doctor of Engineering degree. The objectives are: (1) to afford the engineering student an opportunity of applying his knowledge and education in the solutions of specific practical problems of interest to an industrial firm and (2) to have the student perform in a non-academic environment and thus gain awareness of the organizational approach to problems [1].

The position was secured with the help of Dr. Charles Rodenberger, Assistant Dean of Engineering at Texas A&M

University. Dr. Rodenberger's communications with Mr. Leonard Williams, the technical director at Cameron Iron Works, resulted in a request for the author to interview with Cameron in Houston. Several engineering groups were examined, with the Marine Systems Group, under Mr. Ed Fisher, chosen as the most advantageous for the internship. Marine Systems was considered the most advantageous since its area of responsibility crossed many of the other departments and thus would give the author greater exposure to Cameron.

Cameron Iron Works, with sales of \$461,829,000 in 1978, was founded in 1920 by Harry Cameron and Jim Abercrombie as a machine shop serving the needs of the oil industry. The invention of a blowout preventer in 1922, and improvements made to it, transformed Cameron from a machine shop to a manufacturing company by 1927. Cameron Iron's ownership is shared by over 900 stock holders, the largest being Josephine E. Abercrombie, the daughter of the founder Jim Abercrombie, with control of over one-half the shares [2].

Cameron is divided into three divisions: Ball Valve, Forged Products and Oil Tool.

The author interned with the Oil Tool Division, which comprised 63 percent of Cameron's sales during 1978, and 71 percent of the earnings for the year. Oil Tool is divided into Wellhead, Gate Valve, Control Systems, Drilling Products, Marine R & D and Marine Systems. The author's internship was spent with the Marine Systems Group. Marine Systems is



responsible for designing total production and drilling systems for the offshore petroleum industry. The group has the capability of designing needed equipment for any other Cameron engineering area. This unique responsibility made it the best possible location for an internship. The Wellhead group has responsibility for wellhead and x-mas trees for both land and offshore use. Drilling Products has responsibility for Cameron blowout preventers (BOP), risers, collet connectors and other products used in the drilling operation. Control Systems designs and manufactures various hydraulic and electric control systems for use in the oil industry both on and offshore.

High alloy and speciality steels are forged at Cameron's Forged Products division. Many of the forgings are made from materials produced in Cameron's own melt furnaces. Fifty percent of the forgings made by Forged Products are used in the manufacture of Cameron products giving Cameron the advantage of quality control from start to finish. The landing gear on Boeing 707's, 747's, and Douglas DC-10's are forged at Cameron. Jet engine turbine wheel forgings are also made at the Forged Products division.

Ball Valve is Cameron's smallest division. The division produces ball valves primarily used in oil field production and pipeline service in bore sizes up to 72 inches. This division also manufactures a subsea pipeline tie-in tool.

## CAMERON MARINE DRILLING SYSTEM

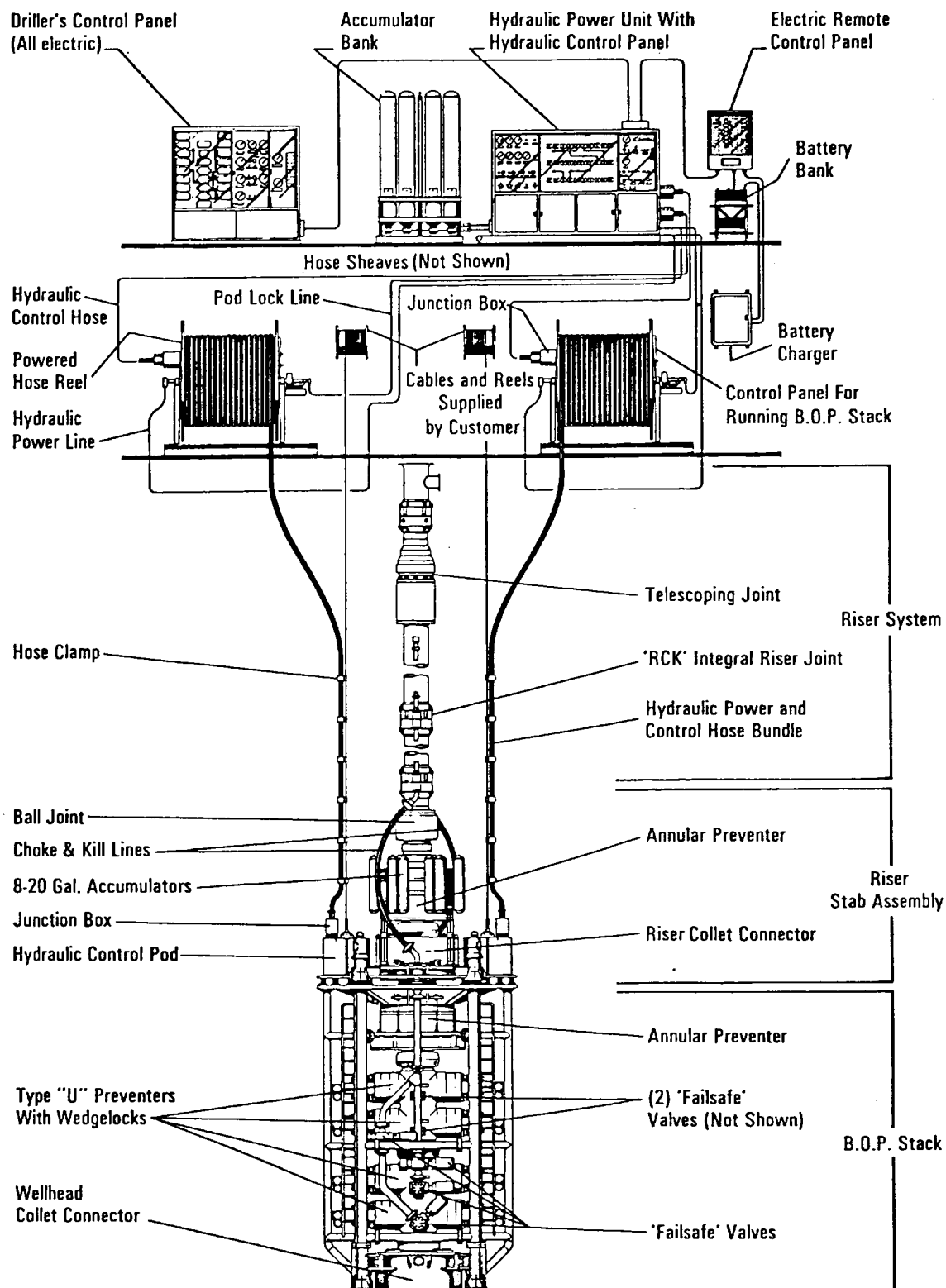
Cameron Iron is a one-responsibility company for many oil field related products. It has the capability to produce a wide variety of finished oil field equipment from steel produced at the Forged Products division. The Cameron Marine Drilling System, parts of which the author contributed to in designing, testing, manufacturing and sales is the standard of the industry. The offshore equipment market is much smaller than the land market; however, it is an important part of Cameron's business. Last year, Cameron Marine Sales accounted for 1/5 of Cameron's total sales, although Cameron had approximately 1/2 of the total offshore market to which it sells.

Cameron produces most of the equipment used in offshore drilling from the rig floor to the wellhead. It does not produce the actual rig or any of the tubular products used in drilling.

### Wellhead and Template

The wellhead and template are the foundation of the total Cameron System. The wellhead is the pressure containing member to which the BOP stack is fastened and through which all drilling is done. The guide base and guidelines allow the BOP stack and other equipment to be easily aligned with the other components. In water deeper than 2,000 feet, a guidelineless

## Cameron Total System



system, television and sonar, guides the various components into place.

### Blowout Preventer

The BOP stack safeguards the surrounding environment and rig against unexpected high-pressure oil and gas which drilling may encounter. It normally contains four ram-type BOP's, one annular BOP and a collet connector. The stack occupies a space of ten feet square and forty feet in height and weights 240,000 pounds. Drilling mud is used to control the pressure of formation and removes the drilling chips. If, however, an unexpected high pressure zone is encountered, the blowout preventers are used until the correct density of mud can be pumped into the hole to control the pressure. The four BOP's are fitted with different size rams to allow closing on both 3.5 and 5 inch drilling pipe. The other BOP's have rams which will shear off any pipe in the hole and a ram to seal on an empty hole. The shear and blind rams are used only in an emergency when it is necessary to disconnect quickly from the BOP for extreme weather or well conditions. In an emergency condition, the closure would be by pipe rams followed by shear rams and then blind rams. The rig could then release itself from the BOP stack and be moved off location until it is safe to return. The stack also contains a bag type preventer which can seal on any size pipe. A collet connector is located at the bottom of the stack which makes a mechanical

pressure-tight connection to the wellhead. The top of the BOP stack has the female receptacles for the control systems to engage matching male stabs and a hub to engage the collet connector of the lower riser package.

### The Lower Riser Package

The lower riser package contains a ball joint, annular preventer, control pods, and collet connector. The ball joint, which the author has spent a large amount of time developing, is the articulating member which takes the bending the riser senses due to current and wave action and the static offset imposed on the riser when the rig is not perfectly located over the wellhead. The annular preventer is a backup to the preventers on the BOP stack. Redundant control pods are connected to the surface by hydraulic hose bundles. The four-inch-diameter bundles contain 50 hoses ranging in size from 1/16 to 1 inch in diameter which are used to control the various subsea hydraulic functions. The pods contain 40 connectors which are hydraulically extended and stabbed into female receptacles in the top of the BOP stack, allowing hydraulic communication between the surface and subsea equipment. A collet connector similar in size to the collet connector on the stack allows a mechanical pressure connection between the BOP stack and lower riser package.

### Anglometers

Anglometers are sensors that electrically monitor the angle of the ball joint directly and the angle of the riser and the BOP stack indirectly. They are located in the pivot pins of the ball joint. The electrical signal is sent to the surface by the multiplex cable on the electric control system or can be connected to the surface by hard wire on a hydraulic system. Signals from the sensors can be displayed on a surface meter showing the location of the rig in relationship to the wellhead. The signal can also be used to control a dynamically positioned ship by tying the signal into onboard computers which control the thrusters holding the ship in position over the well. Measurement of the angle is important as the ball joint must be almost perfectly straight to be able to pass the larger tools. The angle is also important during drilling operations as the drill pipe can keyseat or wear through the riser or ball joint if the rig is off position.

### Riser

The drilling riser links the subsea equipment with the rig. It is constructed of 40 to 80 foot sections that may be fastened together in lengths to reach depths of 6,000 feet. All drilling is done through the riser. During drilling, mud flows down through the drill pipe and up through the annulus between the riser I. D. and the drill pipe O. D. The diameter

of the riser is between 16 and 24 inches depending on the depth capabilities of the rig.

### The Telescoping Joint

The telescoping joint takes the vertical movement of the riser due to the heave of the rig resulting from wave and tide fluctuations. The telescoping joint is connected to the top section of riser and to the ceiling in the moon pool area of the rig.

## ASSIGNED ENGINEERING PROJECTS

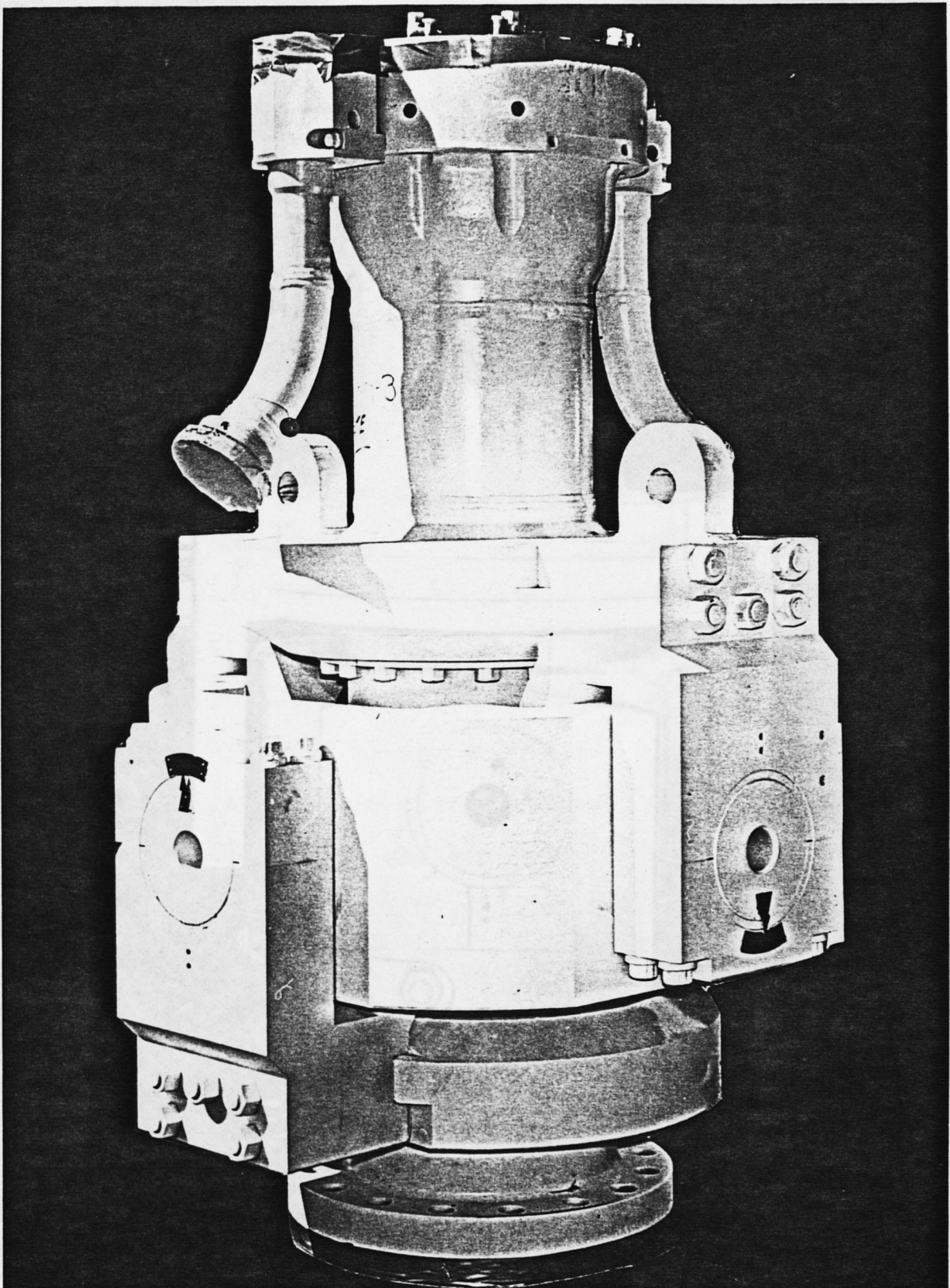
This section deals with the engineering assignments made to the author during the course of his internship. The major areas of responsibility included: (1) product engineering for the universal ball joint line including both new design and redesign; (2) pod seal research and development; and (3) anglogometer redesign.

### Ball Joints

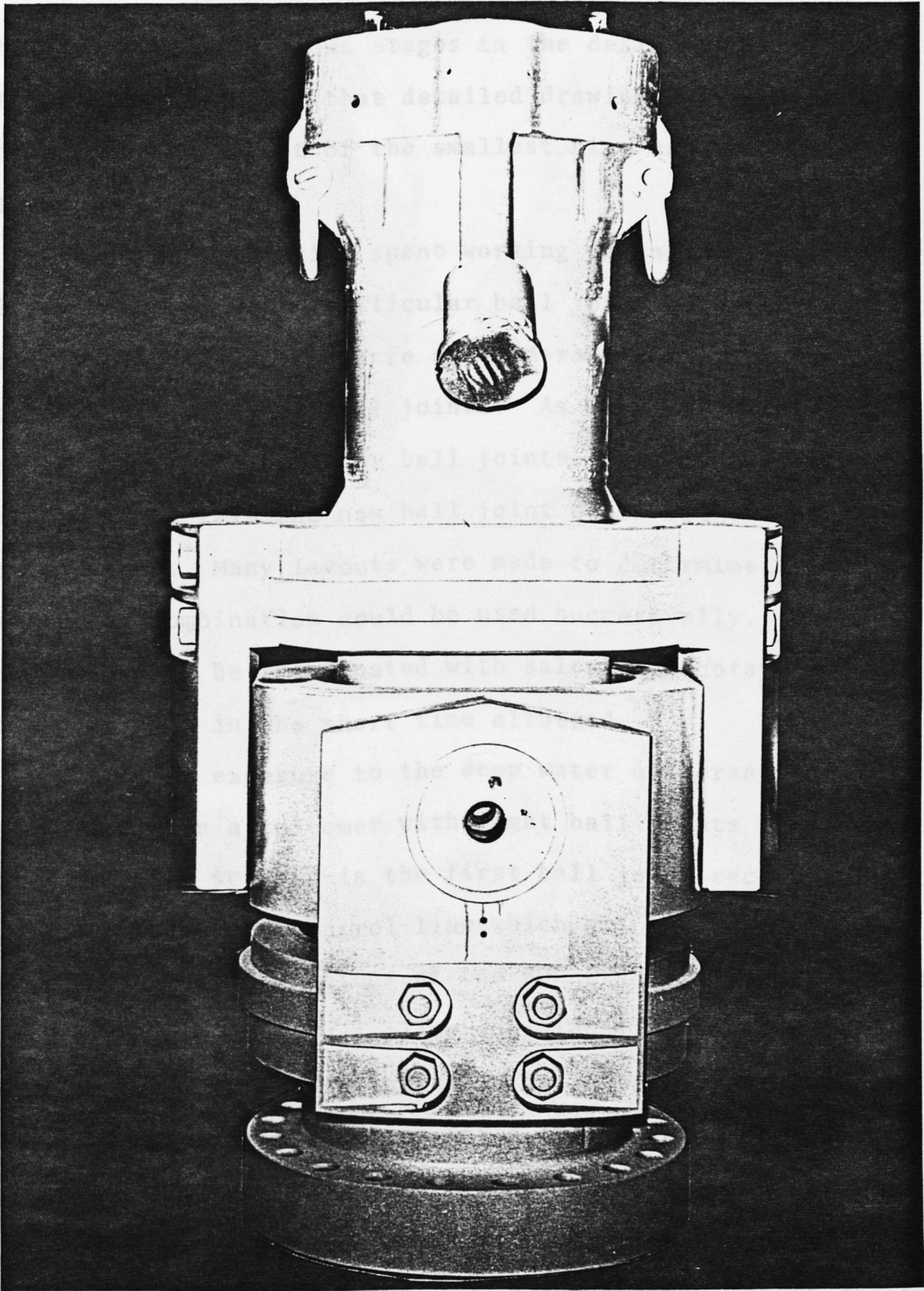
A major portion of the time in Marine Systems Engineering was spent designing and redesigning either complete ball joints or component parts. The Cameron universal ball joint is the articulating member which connects the drilling riser to the lower riser package.

Ball joints are offered in two series for both shallow water and deep water. The shallow water model is rated at a maximum depth of 2,000 feet and a pull of 500,000 pounds. The deep water model is rated for a maximum depth of 6,000 feet water and a pull of 1,000,000 pounds. They are offered with inside diameters of 16 to 24 inches, and are four to five feet in diameter, eight feet high, and weigh between 15,000 and 20,000 pounds. As the deep water model was released at the start of the internship, the work with this model involved updating features and increasing the life of various components. Only one shallow water series had been built at the start of the internship. Others in





Deep Water Universal Ball Joint



Shallow Water Universal Ball Joint

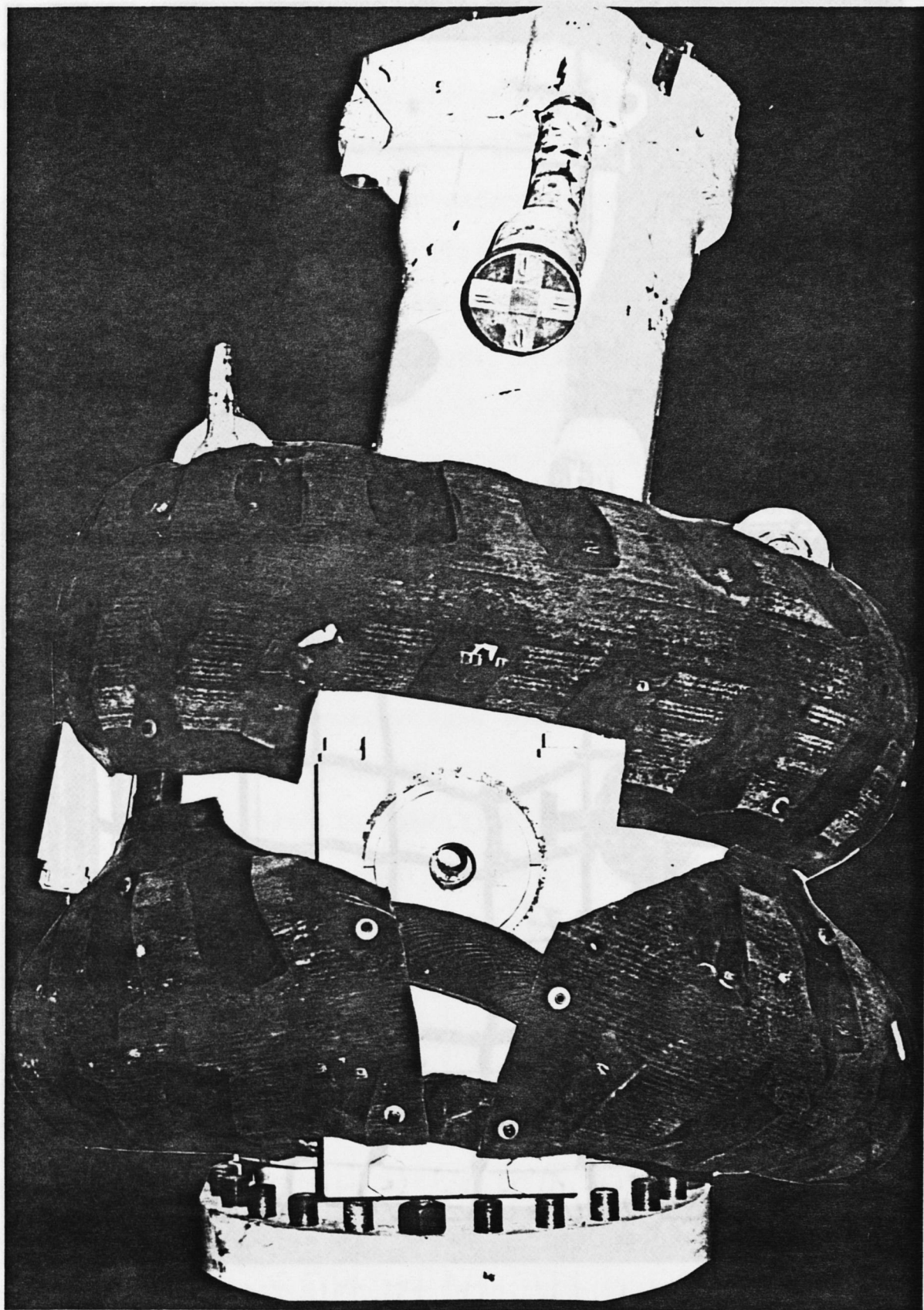
the line were at various stages in the design process. Two of the sizes required that detailed drawings be made, while the design and layout of the smallest size had not yet been started.

Throughout the time spent working in engineering, feasibility requests for a particular ball joint were received from sales and quotations. There are numerous combinations of end connects and sizes of ball joints. As many universal ball joints are replacing older ball joints, careful attention was paid to be certain the new ball joint could fit in the allotted space. Many layouts were made to determine if a particular combination could be used successfully. This, of course, had to be coordinated with sales and quotations and had to be done in the short time allotted.

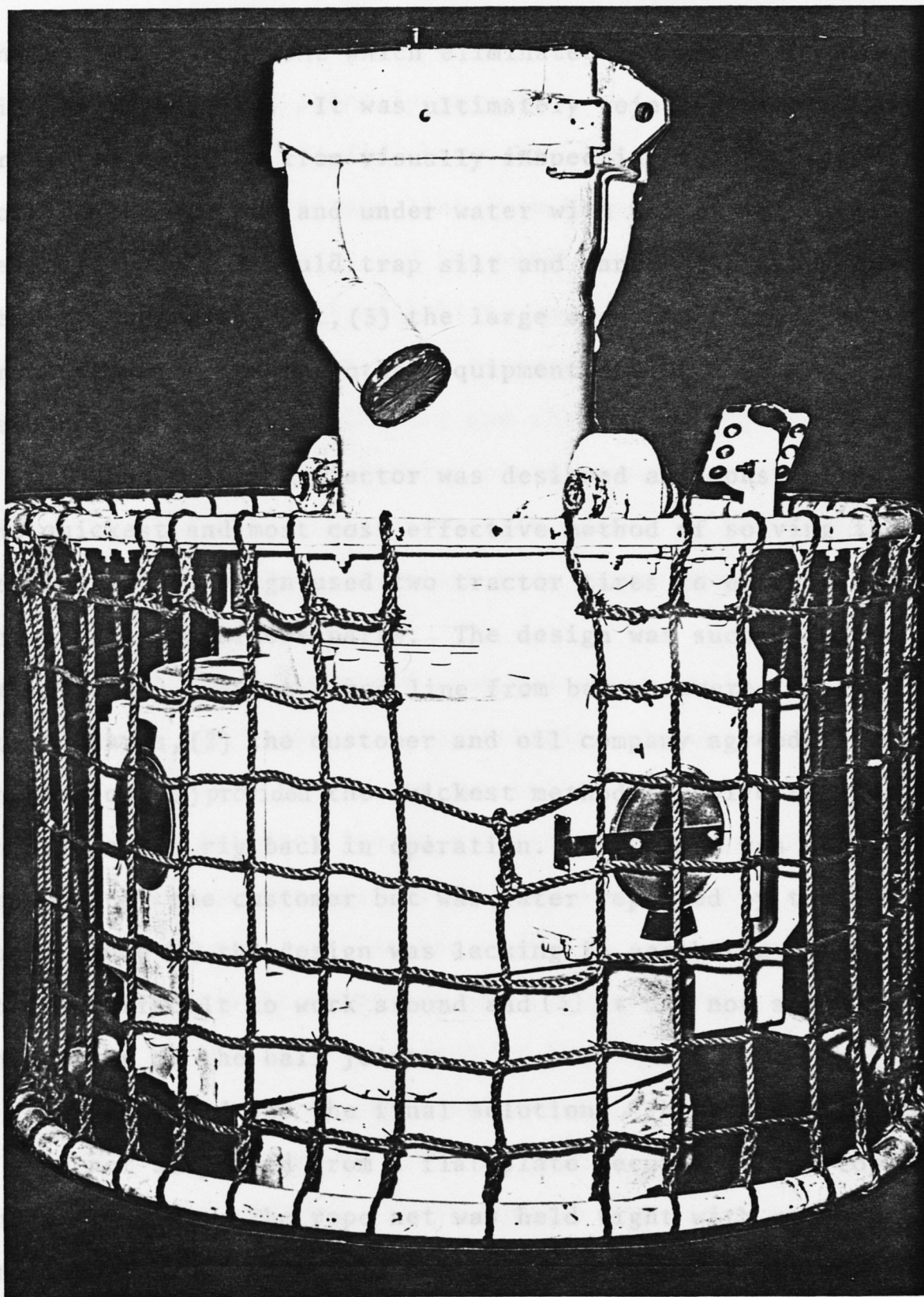
The first exposure to the deep water universal ball joint came when a customer with eight ball joints on order had a pod line severed in the first ball joint received. The pod line is the control line which allows the control of all of the subsea functions of the BOP stack. The oil company leasing the rig would not allow additional drilling until Cameron could design and install a guard to prevent further problems. The request called for a fast solution. Three solutions were proposed: (1) a rubber tire guard; (2) a net guard; and (3) an external ball and socket guard.

A ball and socket guard was perhaps the cleanest design of the three. The ball joint was actually enclosed in a ball





Rubber Tire Guard



Net Guard

and socket arrangement which eliminated any chance of the pod line being severed. It was ultimately rejected since (1) it prevented the crew from visually inspecting the ball joint both on the surface and under water with the aid of divers or television, (2) it could trap silt and sand and cause premature wear of the ball joint, (3) the large diameter might cause problems while running other equipment and (4) time and cost were not in its favor.

A rubber tire protector was designed and constructed as the quickest and most cost effective method of solving the problem. The design used two tractor tires to enclose the potentially hazardous parts. The design was successful because it would (1) prevent a pod line from being severed by the moving parts, (2) the customer and oil company agreed it would do the job, (3) provided the quickest method to solve the problem and place the rig back in operation. The guard was accepted and used by the customer but was later replaced by the net guard since (1) the design was lacking in aesthetic value, (2) it was difficult to work around and (3) it did not allow visual inspection of the ball joint.

A net guard was the final solution. The guard utilized a rope net suspended from a flat plate secured to the top of the ball joint. The rope net was held tight with a 300 pound steel hoop attached to the bottom of the net. There was some concern that the net with its four inch square mesh would trap fish, but a call to the Texas Fish and Game Department

revealed that this would not be a problem. The guard did make working on the ball joint inconvenient and still added cost to the ball joint. It did, however: (1) satisfy the customer; (2) keep the pod line from being severed; (3) allow visual inspection; and (4) serve as an umbrella to keep sand and other solids from falling onto the ball surface.

Once on the rig, an extra feature was quickly discovered by the rig personnel. The net and the support member made an excellent ladder and working platform on which to stand when attaching the first joint of the riser to the ball joint. This unforeseen advantage made acceptance by the rig personnel a reality.

A significant amount of time was spent aiding other engineers in the department to determine the optimum pressure seal and ball coating for the two ball joint lines. The test program included time in the test lab using both full size and scale models also field evaluations. A fixture utilizing a three inch diameter reciprocating rod was used to test various seal compounds and surface coatings. During the course of the test considerable time was spent consulting with various vendors of seals and coatings. The purpose of the vendor contact was to obtain a test sample of the best solution to the problem. These samples were then scale tested in the lab under accelerated wear conditions. A Sacomo urethane seal with an electroless nickel coating was selected from the scale testing. This combination was then endurance-

tested in an actual ball joint mounted in a test frame which allowed the ball joint to be oscillated about its axis to test the life of the seal and coating. The combination, by chance, was also the same combination currently used in the field, reinforcing our initial decision to use the seal-coating combination.

The test program was then extended to field testing of an actual ball joint. Arrangements were made with the rig owner to allow Cameron engineers to visit the rig each time the ball joint came to the surface. This allowed first-hand inspection of the coating and seal along with the overall condition of the ball joint. A total of six trips were made to the Gulf of Mexico for the purpose of inspecting the ball joint. Valuable experience in other areas of offshore drilling was also gained during these trips. Talking with the people who depend on Cameron equipment on a day to day basis yielded a wealth of information about Cameron products. The offshore test program lasted 15 months and proved very worthwhile to both engineering and customer relations.

Paralleling the seal and coating tests was the development of an effective scraper or exclusion ring design to increase the life of both the seal and coating by preventing sand and other abrasives from wearing the ball seal surface. Results from the field tests indicated that the protected ball seal surface was being prematurely worn by sand and sediment deposits collecting on the ball surface. The deposits



were very hard to trace; however, there was a high probability that the abrasives came from the sand blasting equipment used before the ball joint was painted or from sand and dirt deposited on the ball joint during shipping and storage. The purpose of the scraper or exclusion ring was to prevent the abrasives from collecting on the ball surface, thus prematurely wearing the ball and seal. The same piston test fixture used to qualify the seal coating combination was used to check the durability of several different scrapers in combination with the electroless nickel coating.

The challenge in the scraper development came after the particular scraper was chosen. The vendor whose scraper was chosen was located in the Midwest which made personal contact difficult. Fourteen months from the date of ordering, the first acceptable scraper was received. During these 14 months the vendor made several shipments of the incorrect size. The paperwork and scraper were lost and forgotten several times by the vendor. In working with the purchasing department and production control, valuable experience was gained in vendor relations.

At the start of the internship, the deep water ball joint was the only one currently in use. One 21-inch model for shallow water had been built while other sizes in the line were in various stages of the design process. The author was responsible to have the two layouts transformed into working drawings and to design and layout the smallest size

and have working drawings made. Details as to the exact tolerances and material and heat treatment had to be specified and drawings of the various parts had to be checked before they could be released. Time was also spent in the shop assembly area instructing the assembly men on proper assembly procedure.

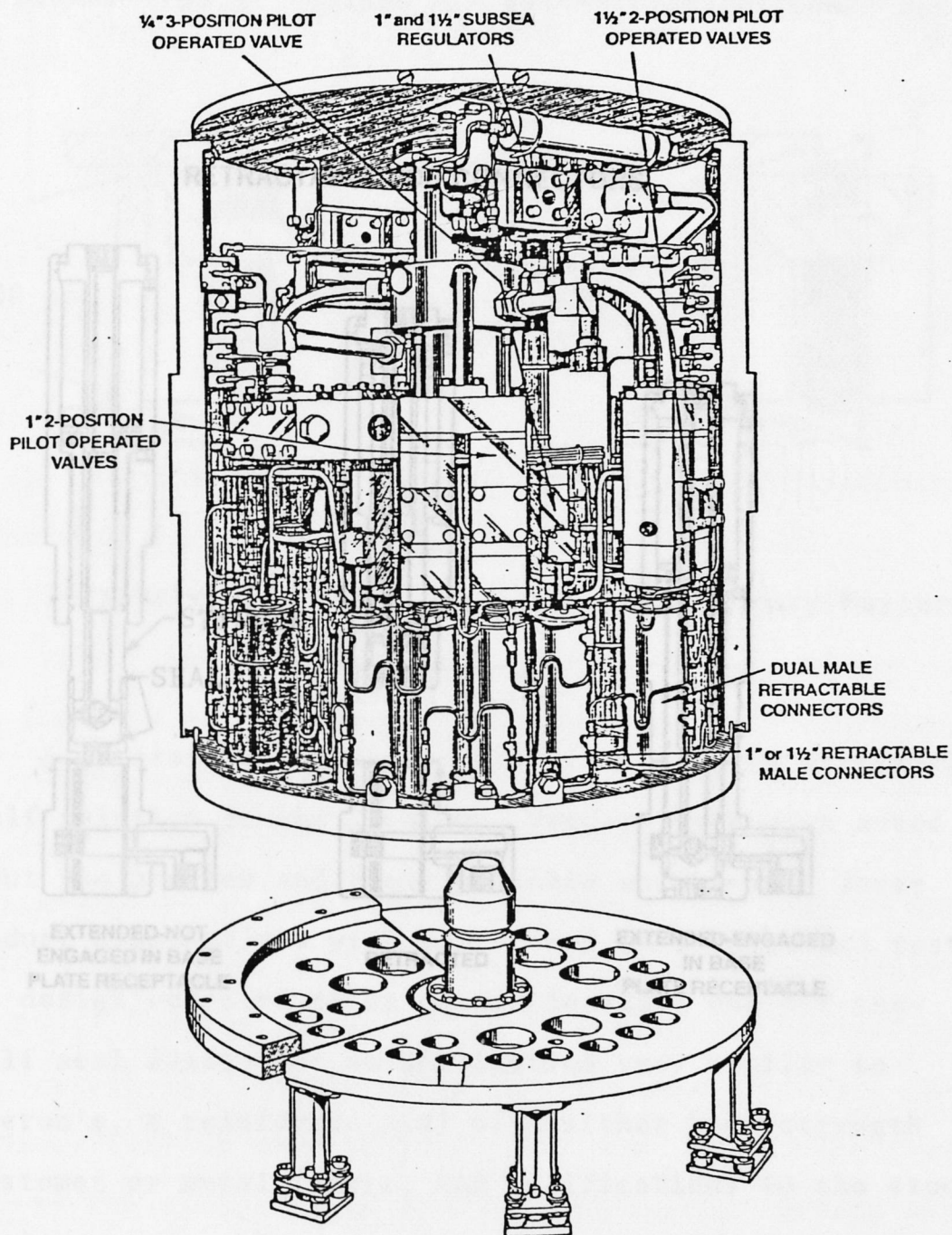
A repair manual for use by the rig personnel was also a requirement of the design. Careful attention had to be paid to instructing the user in such a way as to prevent liability problems to Cameron in case of an accident. At the same time, the manual had to be written so as not to make the ball joint appear to be too difficult to service. This could have been used against us by our competitors. Several drafts were made and changed before the final copy was sent to the technical writing group for final correction to fit Cameron's form and style. Careful attention had to be paid so that the technical meaning of the manual did not change when it was put in Cameron's official form and style.

#### Pod Seal Research and Development

A research and development project was undertaken to develop a new type of seal or other means to make the stinger seals in Cameron's control system more effective. The Cameron control system has been in existence for 15 years and is well respected in the oil industry. However, some

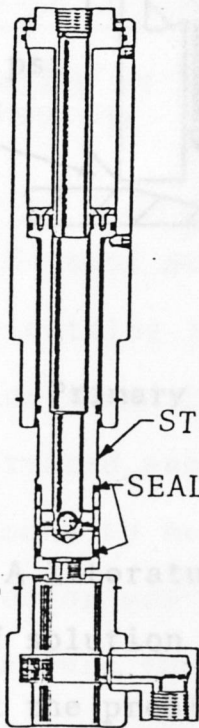
users have had problems with the stinger seals being blown by inexperienced operators. Several safeguards had been tried to prevent the accidental blowing of the seals but all had been directed at eliminating the possibility of the seals being extended under pressure. None of the solutions had been directed at the seals. The pod seals, which number approximately 200 per control system, make a resilient seal between the control pod and the lower riser package. The seals can be blown-off if they are extended or retracted while holding pressure in either the connector body or the female receptacle. The only difference between failures is the position of the seals. The bottom seal fails when extending out of the connector body and the top seal fails when retracting out of the female receptacle. The seals are critical because they control the hydraulic fluid which operates the BOP functions under water.

A test connector was set up in the test lab to determine how the seals failed and to evaluate different designs resulting from the failure testing. The tests revealed that two types of seal failures occurred in the primary failure. The seal is extruded from the widening clearance diameter as the seal is extended from the straight bore into the chambered area. The seal expands until the area exposed to the pressure and the shear strength of the material is equal. At this condition, the seal fails in shear and extrudes from the

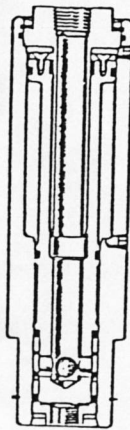


Control Pod

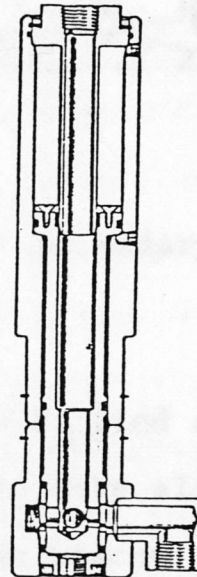
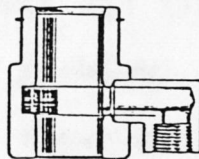
## RETRACTABLE POD CONNECTORS



EXTENDED-NOT  
ENGAGED IN BASE  
PLATE RECEPTACLE

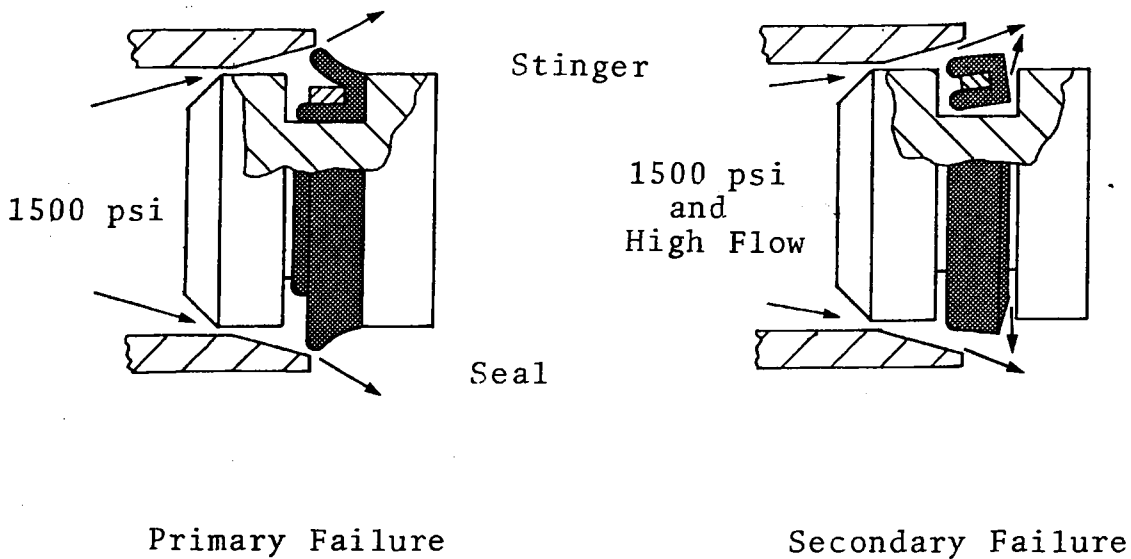


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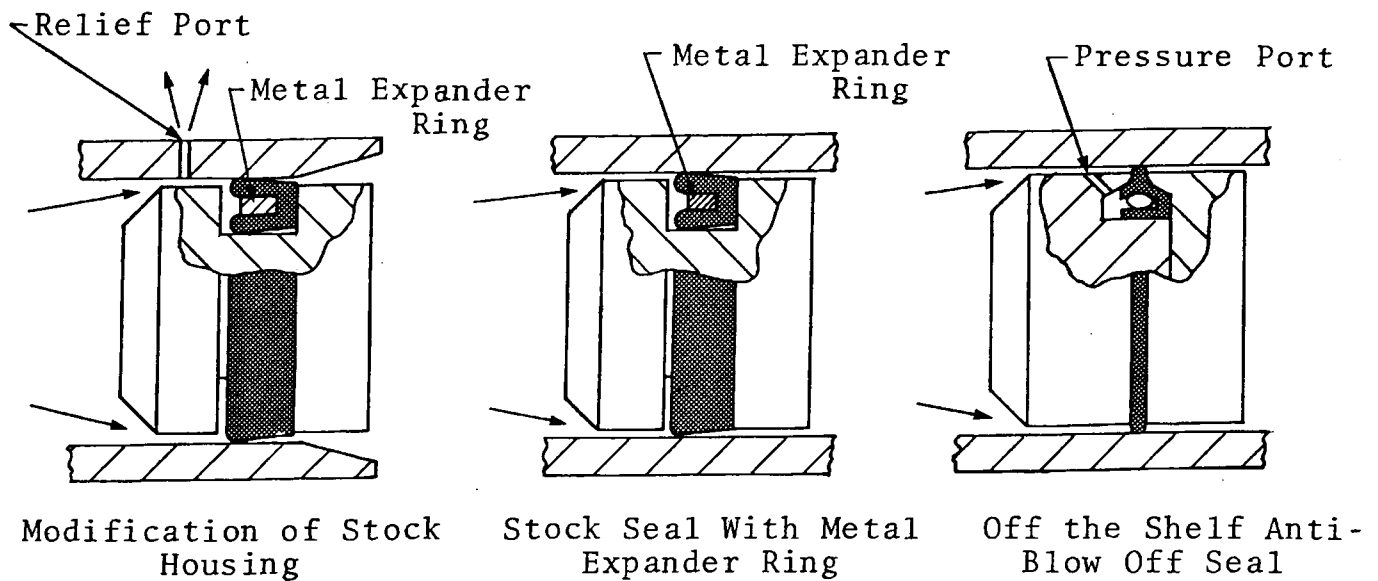


EXTENDED-ENGAGED  
IN BASE  
PLATE RECEPTACLE

clearance diameter. The secondary failure occurs when the high pressure, high flow fluid washes it out of the groove. In either type of failure the rubber expander comes out.



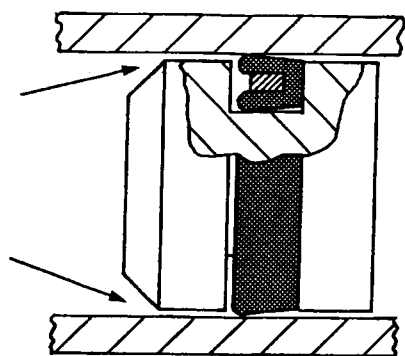
A literature search was conducted to find an off-the-shelf solution to the problem. Vendors were also asked about the problem and their possible solutions. Three product alternatives with variations were built and tested. The design selected to be tested included one off-the-shelf seal design for an application very similar to Cameron's, a reinforced seal with either high strength elastomer or metal insert, and modifications to the stock housing.



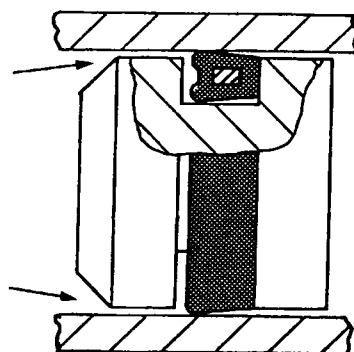
Several seals were purchased from a West Coast vendor whose catalog listed a specially designed teflon seal for applications such as Cameron's. The test samples arrived, were tested, and quickly failed. Their design was analyzed and found to be underdesigned for our pressure requirements. The vendor was notified of the failures and given details of the failure analysis. The vendor agreed the seals were not designed properly and agreed to furnish test samples which would hold up. Several other vendor designs were tested and proved unsuccessful. With the use of air freight, one day service was obtained from the West Coast vendor. A long distance call to the vendor at 8:00 a.m. West Coast time allowed the vendor quick feedback and another design was machined and shipped the same day as the test, starting the cycle over again. The designs never did completely solve the problem, although progress was made during the tests.

The program illustrates the important use of air freight and the telephone in dealing with manufacturers of speciality items used in development. If normal means of shipment and feedback had been used, the success achieved would have been more costly and time consuming. To conduct effective research, quick feedback on both success and failure is necessary.

Several methods of strengthening the present seals were studied. The stock seal was tested with a steel belt in place of the standard rubber expander. This solution was later modified by molding the stock seal shape around a high strength ring. This solution was eventually chosen to be field tested.



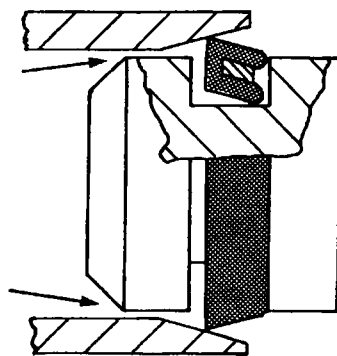
Stock Seal With Metal  
Expander Ring



New Seal With Molded  
in Ring



The stock seal was fitted with a brass ring to replace the rubber expander. This combination quickly failed as the brass ring experienced failure from hoop stresses. The brass ring was next replaced by a high strength steel ring. This combination was tested and found to be promising, as the ring did not fail. However, the lip blew off the seal from the high flow of the escaping fluid. The lip failure was solved by installing the seal with the seal's pressure side toward the atmosphere. The angle of the seal in this position tends to hold the seal in place. This combination was successful, however, further testing revealed that a failure could result if the stinger were slowly extended. Past test procedures had called for a fast extension of the stinger. The failure occurring from the slow movement resulted from the seal twisting or rolling in the groove which raised the heel and exposed it to the high flow.

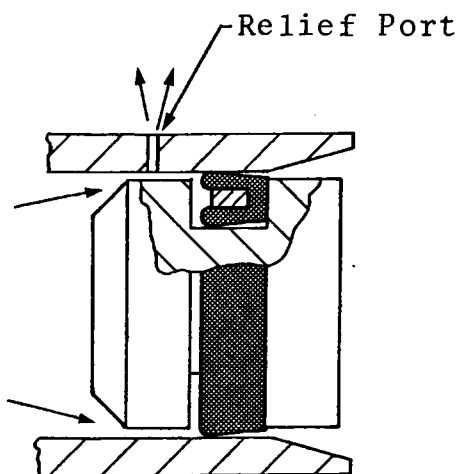


Seal Rolling Out Of Groove

The test program with the separate steel ring led to the development of a steel belted seal. The knowledge gained from the separate ring and seal tests indicated that failure would not occur when the rubber and metal ring were molded together as an integral unit. The vendor of the lip seal was chosen as the company to make the belted seal because of his past record on delivery and his willingness to help find a solution. High strength steel rings with a yield strength of 190 ksi were used. The rings were degreased and sand blasted to insure a good bond to the urethane. Several tests by various Cameron engineers and customers were conducted to try to blow off or otherwise damage the seal. All tests were successful. A field test was arranged on a local customer's rig drilling in the Gulf. A personal trip offshore was required to install the new seals and explain to the rig personnel the proper technique for installation. A test was conducted in the real environment to show the rig personnel that they were in fact a good design and would solve their problem. The long term test has been under way for six months with good results. Six seals have been damaged when the pod was pulled out of the stabs without first retracting the stinger. This was acceptable since the male stingers were also damaged in the accident. The problem at the present is the backlog of orders for the new seals. A patent is pending for these belted seals.

Modification of the bore on the stinger was also

investigated as a possible solution to the seal problem. A series of ports were drilled through the bore of the housing near the bevel,



Modification Of Stock  
Housing

The purpose of these ports or drilled holes was to allow the high pressure and flow to escape while the seal was still constrained by the bore. When the ports were tested in conjunction with the metal ring inserted in the standard seal, the test was successful. Problems were encountered by the seal being gouged as it passed over the ports. This idea was set aside in favor of the steel belted seals. Unfavorable factors for the relief ports were: (1) the connector body had to be removed from the pods to be drilled; (2) the large number of connectors and hoses required in each; (3) the worldwide location of the rigs involved; (4) the ports might become clogged; and (5) the ports gouged the seal as it passed them.

### Anglometer Redesign

An assignment to redesign a set of existing anglometers was the last engineering project undertaken during the internship. The first set had been sold and delivered but did not function as designed. The goals of the assignment were to redesign the existing units and to satisfy the customer with the modifications. The second part of the assignment was just as important as the first as there had been a difference of opinion between the two companies regarding this project and others.

The anglometer sensors are used to determine remotely the angle of the ball joint and indirectly the angle of the stack and the riser. The sensors consist of an electric potentiometer housed in a pressure-balanced oil-filled chamber. With each angular orientation of the potentiometer there is a unique voltage associated with that angle. The angular measurement is important to the rig operator as it determines the rig's position over the well for drilling. If the rig is in the wrong position, damage to the ball joint and the drilling riser will result.

The rig is held in position by thrusters controlled by a computer system. Four different primary sensors are used to provide feedback to the computer on the ship's position in relation to the wellhead. The anglometers are a backup to the four primary sensors. In heavy weather the system was able to hold the rig in 2,800 feet of water within 56 feet of the wellhead at all times.

The project was assigned as a result of the designing engineer changing jobs. The sensors were of basically sound design; however, many of the small details had not been completely solved. The three problem areas were seepage of water shorting the electrical components, calibration, and electrolysis of dissimilar metals.

The water seepage problem was traced to incompatibility of the oil and the rubber bellows and air in the oil. The rubber compound originally chosen for the expansion bladder was from a compound which swelled when exposed to the oil. This allowed water to seep into the chamber and short circuit the electrical components. Residual air in the oil was also a problem. As the sensors were lowered to working depth, the air in the system would compress, collapsing the bellows allowing sea water to short the electrical components.

The water seepage problem was solved by evacuating the air from the oil after filling the sensors, choosing the correct elastomer/oil combination, and designing a schrader valve in one end cap to allow a slight pressurization of the oil.

The calibration problem was solved with a redesign of the mounting bracket. The original mounting bracket required careful attention in assembly to allow the sensor to be within the calibration range of its mounting. The sensors had to be assembled to tolerate a range of 10 percent, which is the maximum for which the original adjustment would compensate. The new bracket could correct any amount of angular adjustment.

It was clearly stamped with angular increments to aid the installer. The material of the mounting was changed from cadmium plated steel to stainless steel to quicken the shipping date.

The electrolysis problem was solved by substituting a nylon bearing for the original brass bearing. The housing material was changed to stainless steel for corrosion resistance.

The units were hand-carried to the rig by another Cameron engineer. They were installed, checked out and working when the Cameron engineer left the rig. The sensors failed within a few days of operation. The customer was quite upset with a second failure in such a short time. The project then went into a third redesign without the benefit of examining the second set of failed sensors. The sensors were still on the bottom, and would be unavailable until it was time to change location, at which time the new sensors were to be delivered.

The third set of sensors were redesigned and built with modifications. The modifications consisted of better clamps attaching the bellows to the housing and the drilling of pressure relief holes in the nylon bearing.

The third set of sensors were hand carried by the author to the rig off Nova Scotia. The purpose of the trip was to get firsthand feedback on the failed sensors, deliver the new sensors on time, and be certain that they were installed correctly.

Upon inspection of the failed sensors, an external electrical connector was found without an O-ring. The missing seal had allowed salt water to leak in and short circuit the connection. No other failures were found. Upon installing and checking the new sensors, the wiring to the computer was found to be backwards. These two problems had been the sole reason for failure of the second set of sensors. The trip did pay dividends in customer relations and also in personal knowledge of the particular drill rig. During the stay on board, very heavy weather was encountered and several guidelineless reentries were witnessed with the aid of subsea television.

## NON-ENGINEERING EXPERIENCE

Throughout the engineering assignments, the author was required to do many non-engineering functions. In Marine Systems Engineering, possibly more so than in other engineering groups at Cameron, a large amount of customer contact is required. Unlike other Cameron engineering projects, many of the Marine Systems projects are for a particular customer and are custom-engineered to his specifications and needs. Marine Systems engineering is in many ways a sales department, or at least more closely tied with sales than the other engineering groups at Cameron. The last six months of the internship were spent completely away from engineering although contact with the engineering groups was necessary. The six months were spent in Inside Sales, Service, Outside Sales, Market Forecasting, and Information Systems. Time was spent in each division to meet people and learn their functions. This section describes these activities.

### Interaction With Customers

A very important part of engineering assignments was to interface with the customer. The oil and gas industry is unlike the consumer goods industry where customers never see the first prototype of the products they are buying. The customer, at least in Marine Systems, participates in design and purchase of the first and sometimes the only unit



produced. Cameron is a large corporation and must function as a large job shop to respond to customer orders. The three most important parts of an engineering assignment are the following: (1) make a design which will function properly; (2) satisfy the customer; and (3) make it at a price which will make Cameron a profit and which the customer can afford. The specific customer dealings are outlined below.

The author worked closely with Zapata Offshore on the ball joint project as Zapata was one of the first local buyers of the deep water universal ball joints. Zapata's nearby location in Houston made communication easy and convenient. Frequent contact was required during design and construction of the guards used to prevent the pod lines from being severed in the ball joint. After the pod line problem was solved, engineering evaluation programs were set up with Zapata to allow Cameron to inspect the ball joint whenever it was on the surface. This program allowed field testing of the ball joint in the offshore environment. Six or more trips were made to the rig to check the condition of the ball joint. The trips also allowed a firsthand look at both drilling equipment and problems encountered during the drilling operation. It also was an opportune time to talk to the rig personnel who used the equipment daily and knew its strengths and weaknesses.

Development of the pod seal also required the cooperation of Zapata. In talking with the Zapata rig personnel,

the author was first exposed to the pod seal problem. In the later stages of development, Zapata inspected and tested the pod seal at Cameron's Houston facility. This led to scheduling an offshore test on one of their rigs in the Gulf of Mexico. As a direct result of the test, a complete set of seals was ordered for all Zapata rigs in the Gulf. The author was able to present Zapata with a quote and take the order for the seals.

The author worked with ODECO on the angrometer sensors. The failure of the first set of sensors made initial contact with the customer uneasy. The relation was also strained from other past problems with Cameron equipment and delivery. Close communication and keeping promised delivery dates helped smooth out the relationship. Several meetings and long distance phone calls were required to get the project on an even keel. A trip to the rig off Nova Scotia was used to deliver the sensors and to insure the indicators were working properly before the customer had to rely on them. Again the trip to the rig brought a high rate of return in terms of getting to know the drilling equipment and the customer's rig personnel.

#### Interfacing With Other Engineering Divisions

Contact with other engineering divisions at Cameron was needed when working with both the pod seals and the angrometers. Both projects required the cooperation of

Cameron's Control Division. Marine Systems had received both projects, as Controls did not have the manpower to develop them; however, care had to be taken not to infringe on their area of responsibility. Assistance from them had to be given: It could not be ordered, as the group had more urgent priorities. Without the Controls Group help, neither project would have been successful. At the end of the internship, the pod seal development had been turned over to the Controls Group although the angle indicator project was still in Marine Systems.

### Assignments Outside Engineering

A very rewarding and possibly unique feature of the internship was the six month period spent outside of engineering. Several weeks were spent in each of Sales, Service, Market Forecasting, and Information Systems. Throughout the time spent in engineering, some contact had been made with each of these groups. The time spent in each of the areas better defined the function of each group, and possibly more important, the names and faces of the people in these groups. The specific departments and experience at each are outlined below.

### Inside Sales

The Inside Sales group is broken into six groups: Customer Sales, Customer Response, Quotes, Pricing, Warehouse Sales, and Subsidiaries Sales. Several days to a

week were spent in each of the areas. In Customer Sales, the author participated in making engineering requests to the engineering departments. He learned the flow of paper work and the types of sales the group deals with on a day-to-day basis. One week was spent working with the Customer Response group, whose function is to handle all hot and troubled orders. The group handles orders made by customers who must have fast turnaround for parts or equipment built in our facility. They also handle customer complaints involving slow deliveries and malfunctioning equipment. Time was spent in the quotation department learning the paper-work flow and meeting people in the various groups within the department. One very enlightening week was spent with the pricing group learning Cameron's pricing policies. Although engineering frequently works with pricing, the author was better able to learn just how the pricing, policies of Cameron are applied also cost and selling prices figured by working directly with pricing. Another week was spent with Warehouse and Subsidiaries Sales learning the paper flow and functions of these two similar departments. The departments are very close in responsibility, except Subsidiaries are simply foreign warehouses. The responsibility of both groups is to transfer inventory to the proper location on time.

### Outside Sales

Two weeks were spent with the Outside Sales Group calling

on customers in the Houston Area. Again a better understanding of the sales function was gained by working with a salesman as he did his daily duties. Engineering interfaces with Sales to a large extent; however, working with Sales daily allowed the author to observe the groundwork sales completes before engineering is involved. A major function of Sales is to assist the customer even if it will probably not result in a direct sale. Several days were spent helping a customer sell his Cameron equipment to another customer. Oil field sales uses more of the "helping hand" technique of selling opposed to the aggressive selling as illustrated by consumer goods sales. Aggressive selling is sometimes needed to close the deal after much groundwork in terms of relations with the customer has been completed.

### Service

Working with the Service Department required being on call 24 hours a day. Engineers, particularly in Marine Systems, are exposed to a large amount of service work. The work tends to be somewhat other than routine when an engineer is called to the field. Working with the Service Department exposed the author to the routine service work in which he had never been able to participate. During the tour with the Service Group the author was able to test a casing head, set a back pressure valve, decomplete a well, and set tubing hangers on a dual completion. The service calls required the author to sleep in the back seat of a company car for

several nights and to spend several days offshore on a production platform. These trips allowed the author to spend time around both a land rig and a marine production platform which he had not been able to do as a Marine Systems Engineer.

### Market Forecasting

The broad background received during the internship was put to good use in working with the Market Forecasting Group at Cameron. The author was able to participate in the development of a five-year plan which gave Cameron management a look at the future for oil and gas equipment sales world-wide and help management plan for Cameron's expansion. It also predicted the percent of the marketplace that was potentially Cameron's and the percent Cameron could reasonably expect to receive.

The forecast relies on an accurate inventorying of the various rigs by types throughout the world. The world was divided into areas corresponding to the sales districts so the forecast could be used to aid each district's management in their market plans. A list of the number of various types of rigs in the region was produced. The information of the total rigs was then taken from the Offshore Rig Locator, API Bulletins, and other oil field publications. The finished list contained the number of drill ships, barges, jackups, semisubmersibles, platform rigs, platforms, and land rigs in the region. The list also specified the number of these which were actually drilling or were available

for contract. The list took into account the number of rigs under construction and the number of rigs which were likely to be retired due to age or accident. The total average number of holes a rig could drill in a year was also listed. A study was then conducted to determine the volume or type of equipment a particular type of rig would consume for each hole drilled. Having this information, the total potential market for each type of Cameron equipment was then forecasted by regions of the world. Cameron's share of this market was forecasted by looking at its past performance and the capacities of both Cameron and its competitors.

The background experience received in other departments at Cameron and with customer contacts proved invaluable in participating in the forecast.

### Information Systems

Working with the Information Systems Group in computer services provided a background regarding what is involved in making a computer report available to management. The project assigned during this month was one dealing with the yields received from ingots and billets in the Forged Products Division. The project was assigned since it was one of the few programs in the group which was to use Fortran, the standard languages being PL1 or COBOL. The program originated in Forged Products Engineering and was running when the responsible engineer left Cameron Iron Works. The assignment was to get the program running again, update it with current information, instruct

the new personnel how to use it, and bring the program from UCS time-sharing to the inhouse computer. Upon receiving the assignment, the author found that all of the information had been accidentally dumped before it was recorded on tapes. After much hunting he was able to recover the old programs and last recorded data from the timesharing dump files. Several weeks were spent working with the old program to become familiar with it. The ex-Cameron engineer and his co-op student were located and consulted concerning the program. The program was then rerun with old information to determine whether or not the program had, in fact, been recovered. A report of the current status and the recommendations for its use were then presented to the Industrial Engineering Management in Forged Products. High manpower requirements to keep the system operating caused the project to be cancelled.



## COMMUNITY INVOLVEMENT

During the course of the internship, the author had an opportunity to participate in community affairs. He attended several property owners meetings, civic club meetings, and social functions sponsored by the two groups. The author also organized and managed a fund raising project for the civic club.

The fund raising project was in the form of a water ski tournament. With the help of several other members of the community he was able to raise \$900 for the civic club. Careful soliciting yielded donations of food and equipment which made possible the large profit from the function. The community benefitted from the project in terms of entertainment and recreation it offered to both participants and observers. The tournament indirectly speeded up the developer into doing some needed repairs to the community center. The tournament was also used to introduce a new age division to tournament water skiing: Children ages seven and under were able to compete against themselves instead of with other children up to age 12 as the American Water Ski Association Rules call for. The tournament yielded the community rich rewards and allowed the author to practice management of a large community project. The author gained valuable news media experience when arranging with the local paper for news coverage.

## SUMMARY

The internship is the highlight of the Doctor of Engineering program. It was the deciding factor in choosing the Doctor of Engineering program over other graduate programs in engineering and business. The Doctor of Engineering student takes many of the same courses other graduates do; however, the other graduate students are normally not given an opportunity to serve an internship as is required of the Doctor of Engineering student. The internship allows the student to make a major engineering contribution to the company and to look at a particular company from a point of view that none but a few top company personnel have ever been able to observe. Employees fortunate enough to have the experience equal to the internship have been forced to accumulate it over long years of employment with the company. Visibility is another key feature of the internship, as the intern works in different departments.

The most important lesson learned while on internship is the importance of people to engineering. Knowing the names, faces, and job responsibilities of employees in different departments is of great importance to the engineer. Employees within the company perform a better, quicker job if they know the employee making the request. The internship allowed the intern to meet the various employees in the company and benefit from their friendship.

The least desirable feature of the internship was its location within the program. The internship is normally scheduled with one semester of course work remaining which must be completed at Texas A&M University. This requires the intern to move three times during the transition between the University and industry. The moves are particularly burdensome upon interns with families. The location of the internship within the degree program is also of concern to single students and may be one negative factor against the Doctor of Engineering program.

## REFERENCES

1. "Guidelines for Doctor of Engineering Internship Report," College of Engineering, Texas A&M University, College Station, Texas.
2. "History of Cameron Iron Works," Albert Van Helden, 1971.

## VITA

John Platou was born January 5, 1951, to Liev and Betty Platou in Toledo, Ohio. He attended Westbury High School in Houston, Texas, graduating in 1969.

He entered Texas A&M University in the fall of 1969 majoring in Mechanical Engineering. After receiving his B.S. in Mechanical Engineering in December of 1973, he worked as a research and development engineer for Mercury Marine in Oshkosh, Wisconsin. He remained at Mercury Marine for eighteen months before entering graduate school at Texas A&M University in the fall of 1975.

Mr. Platou was accepted into the Doctor of Engineering program during the spring of 1976. He received a Master of Engineering degree in Interdisciplinary Engineering in August of 1976. The Doctor of Engineering internship was served in Houston, Texas, at Cameron Iron Works. He expects to remain with Cameron Iron Works after receiving his Doctor of Engineering degree in May of 1979.

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